Closeup of concrete beam failure shows severity of deterioration due to corroded reinforcement.

We've known for a long time that steel reinforcement is necessary in most concrete construction work. But it can be a potential destroyer, too. Here's a story of a failure that could have been prevented, if a few quite simple precautions had been taken.

CORRODED REINFORCEMENT

WRITING IN A RECENT ISSUE of *Civil Engineering* magazine, Professor Carl T. Shermer of Michigan State University makes some interesting observations concerning the destructive potentialities of corroded reinforcement in concrete beams. Although the specific example he writes about involves precast concrete beams, and the conditions of exposure are more severe than most, there are still some worthwhile warnings for those who are responsible for job-cast reinforced concrete construction subject to normal exposure.

The beams Professor Shermer writes about are precast I-type members installed in 1947 to support the roofs of lumber drying kilns at the Brunswick-Balke-Collendar Company at Muskegon, Michigan. Under exposure to the warm moist atmosphere inside the kilns, and with no protection for the reinforcement except that provided by the concrete of the beams themselves, steel corrosion advanced rapidly enough to cause structural failure in 1955 under the dead load alone. Corrosion was sufficient to reduce the diameter of some ⅞-inch round bars to ½ inch or less.

The concrete itself was of a fair quality. Small specimens cut from the beams tested from 3,000 to 4,000 p.s.i. Functioning as a consultant called in after the failure, Professor Shermer reached the conclusion that the beams were literally burst apart by the corrosion of the reinforcing steel. The expansion of the metal as it oxidized set up disruptive stresses that the concrete could not withstand.

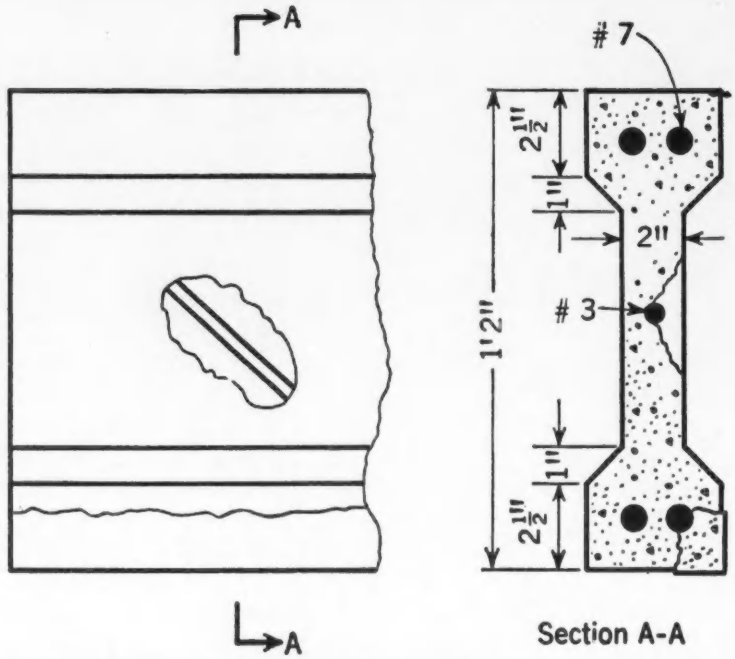
But why the corrosion in the first place? Professor Shermer is convinced that there was not enough concrete over the reinforcing steel to protect it from exposure to air and moisture.

He notes that the longitudinal steel caused very noticeable cracks which often extended the full length of a beam along one or more faces of the flanges, and that the ⅜-inch diagonal web bars in several instances simply popped the concrete from one face of the web, leaving the steel completely exposed as shown in the sketch. Cracking progressed most rapidly near the ends of the beams, and in each case where the beam actually failed, the failure occurred close to the support. Professor Shermer believes that this is explainable on the basis of loss of bond between the steel and the concrete and the presence of greatest shearing stresses near the supports.

Precast channel-shaped roof slabs, and cast-in-place concrete floors in the same structure showed no evidences of distress, a fact which seems to confirm the conclusion that the beams failed because of steel corrosion. Since the roof slabs also contained steel, and were cast in the same factory and at about the same time as the beams, the investigators looked for and found a qualitative difference between the con-

crete in the slabs and that in the beams. They concluded that the greater difficulty of casting the narrow beams with their relatively large volume of steel led the manufacturer to use wetter concrete for this purpose than was necessary in the case of the slabs. Thus the beam concrete, even though it was of fair quality, was probably inferior to the slab concrete in both strength and density—its greater porosity permitting the penetration of air and moisture which led to the eventual failure.

Professor Shermer, in concluding his discussion, emphasizes the importance of providing good protection for reinforcement steel in damp locations. He suggests that this can be accomplished by one or more of the following methods: (1) use of good quality concrete; (2) maintenance of a sufficient distance between the steel and the exposed concrete surfaces; and (3) use of water-proofing applied to the concrete. We're tempted to add one conclusion of our own: whether you're site casting or precasting. *DON'T* throw water into your concrete to make it easier to handle; the results are almost unfailingly bad. END.



Reinforcing bars, expanded by oxidation, burst beam concrete which was exposed to warm moist air in lumber drying kilns.

Beam failure occurred at points of high shear, probably because of slippage of corroded reinforcement.

Photos courtesy Brunswick-Balke-Collendar Co.

Photo courtesy of Electromode Corporation

In upper left corner one cable anchor is fastened directly into concrete; others are secured to nailing strip.

NEW CABLE ANCHOR

provides speedy means of placing electric cables in concrete slabs for radiant heating and snow-melting systems

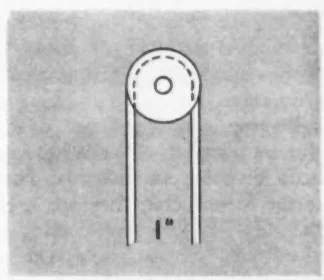
BECAUSE OF THE GROWING INTEREST in radiant heating and snow-melting systems for drives and walkways, it is increasingly common these days to encounter job specifications that call for locating insulated electric cables in concrete slabs at the time they are poured. Although the electrical contractor is responsible for the actual installation of the cable, the concrete contractor is very directly concerned with such problems as cable spacing and the provision of a dependable anchorage.. He also has an important stake in preventing excessive delay in the cable installation, since his men and equipment are necessarily idle while this operation is carried out.

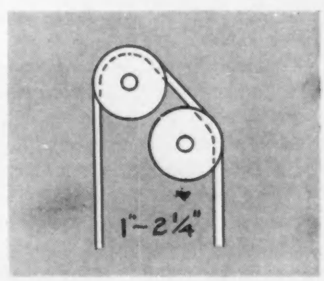
Anchorage usually presents the most difficult problem. Of the several methods developed, one makes use of expanded metal frames to which the cable is tied, another involves driving large staples into the green concrete, and a third requires weighting the cable with patches of plastic concrete. None of these methods seems wholly satisfactory. They are all time consuming, they do not hold the cable taut, and they provide no protection for the cable during the installation.

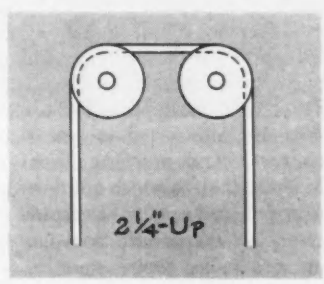
The special anchor shown in the accompanying pictures was developed to solve these very problems. It consists simply of two circular fiber discs, one of larger diameter than the other, with a hole through the center. One anchor provides for minimum cable spacing of 1 inch, but the use of two anchors for each cable loop will make provision for any desired spacing greater than 1 inch (see sketch).

The anchors are placed by simply nailing them into strips of wood set in the base concrete, or by means of special nails driven directly into the base concrete. The small disc in each anchor is thick enough to keep the cable from being crushed, and its shape permits the cable to wind back and forth without being kinked. The larger disc, which must be on top, holds the cable down firmly to the base and prevents it from slipping off the smaller disc. In the subsequent concrete pouring operations, cables anchored in this fashion are said to remain firmly in place without incurring damage from wheelbarrows or power buggies.

Contractors who have used these anchors report that they save time and labor and do a beter job than was possible with the methods described above. No special tools or skills are demanded, and the anchors themselves are quite inexpensive. END







Granolithic Concrete Floors . . .

they have important advantages when surfaces are likely to be subjected to severe wear

BY J. E. JELLICK

FROM THE STANDPOINT of their need to withstand wear, floors constitute the most important feature of modern industrial plants, warehouses and similar buildings. But they also represent only a very small fraction of the total cost of such buildings.

The floor finish plays an important part in the successful operation of a factory. Basic requirements for an ideal floor finish are that it should be economical, resistant to wear, impervious, sanitary, fire resistant, skidproof, inert, easy to maintain and to keep clean.

Because concrete floors offer the greatest number of prime characteristics desirable in industrial flooring at the lowest cost, they are used in more than 90 per cent of plant areas. A small portion is covered with other finish materials, but generally concrete floor surfaces are specified for the major exposed areas.

Concrete finish in many factories with constant traffic by small wheeled trucks is subject to more severe wear than is concrete in road and bridge slabs. This emphasizes the importance of laying concrete floors with no stinting on material, or labor, and in strict observance of the rules for good construction proved by experience and tests.

There are essentially two types of concrete floors used in industrial plants — monolithic and granolithic. The monolithic type requires that the floor be constructed as one slab of concrete (no topping involved). Monolithic slabs which are floated and troweled make good structural concrete, but the surface does not stand up well under severe wear.

A monolithic floor finish can be very greatly improved in quality and durability by the addition of a surface finish, including coarse size granitic or basaltic rock, but the addition of such materials requires a special technique and the work must be done by qualified organizations.

Another method is to depress the slab from ¾ of an inch to 1 inch and then install a separate wearing course using materials and procedures that produce much greater density, strength, toughness and wear resistance.

Satisfactory installation of a granolithic topping requires a specialist organization, for it involves technical experience to properly select the materials, and highly skilled workmen with the know-how to perform each of the successive operations required.

A special "absorption process" granolithic floor topping developed some 40 years ago has an extremely high density, although it consists of essentially the same materials as found in conventional concrete floors. These floors get their exceedingly high wear resistance, and their high degree of imperviousness, from the method used to lay them. The life of such granolithic floors, free from maintenance, even under severe conditions, is a minimum of 30 years, making them by far the cheapest industrial floors for exceptionally rugged applications, despite their relatively high initial cost.

Granolithic topping is applied either on a fresh slab, or as one of the last operations after heavy construction is finished. Good granolithic floors consist of portland cement, sand, and specially selected hard, tough basaltic or granitic rock. A proper low water-cement ratio results in concrete having maximum strength and toughness. The minimum is 29 per cent by weight or approximately 3 to 3½ gallons of water to one bag of cement. Too much water can result in shrinkage, curling, cracking and pulling away of the topping from the slab or fill.

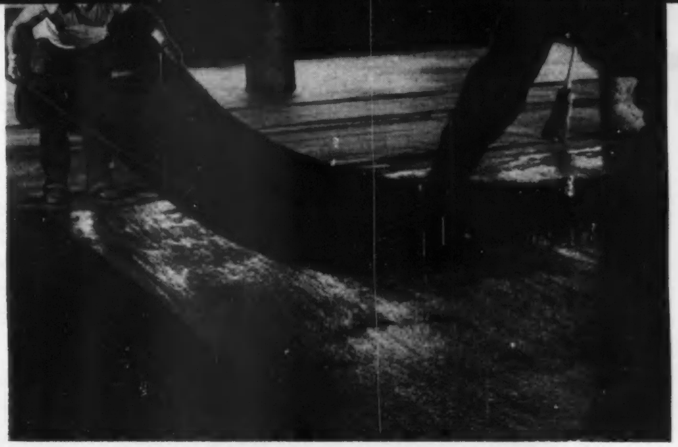
The absorption process method uses up to five gallons of water per bag of cement. This is enough for complete hydration. After the topping has been poured and leveled, the excess water is withdrawn to the proper specifications by applying an absorptive blanket. Withdrawing the excess water provides a topping of unusual density, hardness, and durability. The water is absorbed without disturbing the aggregates or bringing the fine matter from the bottom to the top. It also produces a suction bond to the slab.

The absorption process topping may have a crushing strength from 8,000 to 10,000 psi, as contrasted with most monolithic slabs which average 2,500 to 3,000 psi. The type of abrasives which might be included in the floor depends entirely on the type of traffic. Emery, aluminum oxide, alundum and carborundum are usually used.

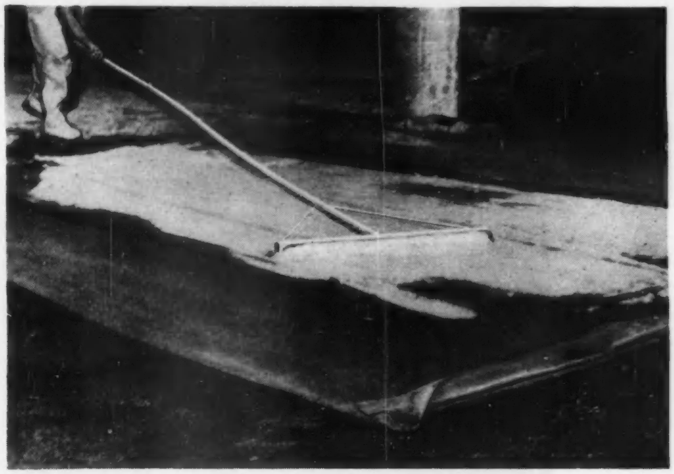
Absorption process floors are impervious to oil spillage, provided the surface is given normal care. They have excellent non-dusting characteristics, and maintain hard, uniform surfaces free from breaks and surface ruts over long periods of time. END

(The illustrations on the facing page show the absorption process method in granolithic floor topping.)

Step One. After preliminary preparations, including wire brushing and wetting the base slab and working in grout coat, the first step in applying an absorption process granolithic concrete floor is to place and screed the concrete mix, which contains just enough water to permit easy workability.



Step Two. The absorption blankets are then placed on top of the freshly placed and screeded floor.



Step Three. Next the drying mixture is spread on top of the absorption blankets. This acts as a blotting agent and through capillary action absorbs the moisture below the surface.

Step Four. After the proper time has elapsed for obtaining correct water-cement balance, the absorption blankets are lifted revealing a topping that can immediately support the weight of a man without indentation. Next comes the finishing operations which include both mechanical and hand troweling.

Photos courtesy Dow Chemical Co.

This view, which also appears on the cover, demonstrates a new method for forming transverse contraction joints. It was developed from tests made by the Michigan State Highway Department and is illustrated here by paving operations on U. S. 127 in Michigan. A T-shaped metal bar with a 2½-inch vertical leg is used to form the joint groove in the slab every 99 feet. This operation immediately follows the longitudinal float. After the metal bar has been removed, the groove is prepared for the insertion of strips of plastic foam. As soon as the strips are in place, hand finishing operations restore the concrete surface to a smooth condition in the joint area.

Hand tools are used to remove the plastic filler material after the concrete has set. The joint is then sandblasted and sealed.

Perimeter insulation, pavement jointing material or temperature equalizer in giant dams—it's all in the day's work for . . .

RIGID PLASTIC FOAM

A RIGID PLASTIC FOAM material is being adapted to a number of interesting uses in the concrete construction field. Said to be the lightest of all rigid insulation materials, it combines low thermal conductivity with high resistance to water and water vapor.

This happy combination of characteristics has led to some interesting applications of the product in foundation and slab work as either horizontal or vertical perimeter insulation, for full insulation under slab-on-ground construction, and for insulating perimeter heating systems. It is also showing up as concrete road jointing material, and is even playing an important role in the construction of a $69 million dam involving the placement of 1.3 million cubic yards of concrete. Other major applications include its use as a combination insulation and plaster-base material in masonry homes, and as a core in sandwich panels having skins of concrete or other materials.

This product of many uses is made by expanding a plastic called polystyrene to approximately 40 times its initial volume. The resulting material is composed of a system of millions of small, non-interconnecting cells. Although it weighs only 2.4 ounces per board foot, it is said to have an average compressive strength of 3000 pounds per square foot. One important advantage of this relatively high strength is that concrete floors can be poured directly over the material without providing additional support.

The material is sold by board-foot measure, just as lumber is, and it comes in various widths and thicknesses, packaged in 3-foot lengths, or unpackaged in 9-foot lengths in carload or truckload quantities.

For perimeter insulation purposes, 1-inch thick boards are installed either horizontally or vertically to a width

of 12 to 24 inches, depending on climatic condition and job requirements (see illustration). In horizontal applications the foam boards are simply placed on well-tamped fill and the concrete slab is poured directly over them, while in vertical installations the boards are applied to the inside of the foundation walls before the backfill is shoveled in. Although the pressure of the backfill is sufficient to keep the insulation in place, the boards may be bonded to the foundation with portland cement mortar or cold-setting asphalt adhesive. In all such installations, of course, the main objective is to do away with any solid masonry link between the foundation wall and the slab.

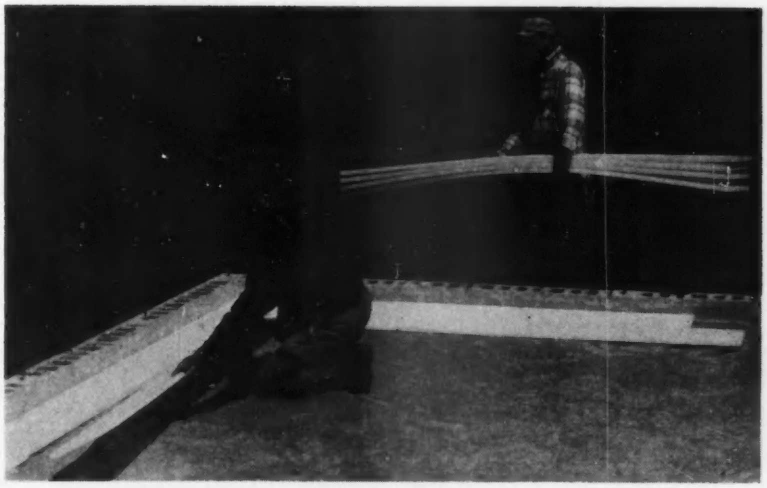
For perimeter heating installations, where excessive heat loss is likely to result from the large temperature differential between duct and ground, the rigid planks are often used to completely isolate the ducts from both the ground and the foundation walls. When it is desirable that an entire slab-on-grade floor be kept warm and dry, the planks are laid on well-tamped fill and covered with wire mesh reinforcement before the concrete is poured.

Even when the plastic planks are totally immersed in water for extended periods, as can well happen in the types of installation we have been discussing, it is believed that only the open surface cells will retain moisture. Of equal importance is the fact that the material is highly resistant to rot and fungus growth, and it has no food value to attract rodents or insects.

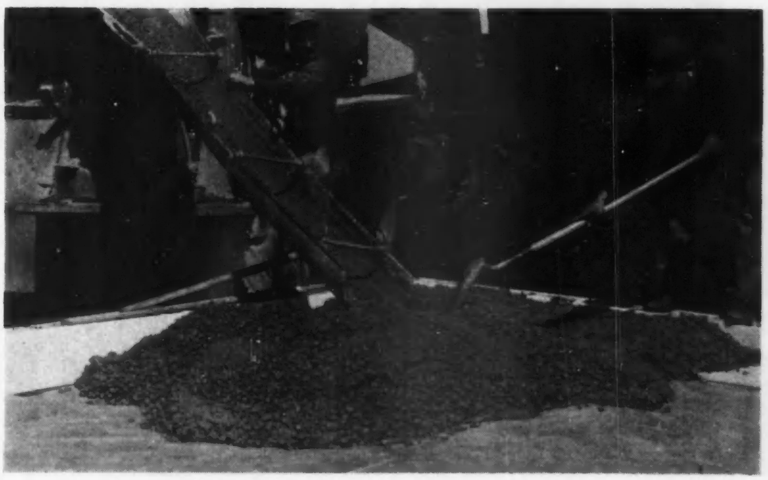
In the highway pavement application mentioned earlier, ½- by 2-inch strips of the rigid foam are used in place of regular asphalt-impregnated fiber board to form transverse contraction joints. The slab is grooved with a joint bar and the strips of plastic foam are fed in, leveled and straightened manually, and the finishing operations proceed. In addition to forming the groove, the plastic acts as a temporary filler to keep the joints free of debris. It is believed that the natural resilience of the material is responsible for a reduction in spalling at the joints.

After the concrete has set and shouldering operations are completed, the strips are pulled out with hooks, and the joints are blown out with compressed air and sealed in the conventional manner. Some 150 miles of

For vertical perimeter insulation, boards of plastic foam may be bonded to the foundation with portland cement mortar. However, the dry boards are generally placed in position as the backfill is accomplished eliminating the need for an adhesive backing.



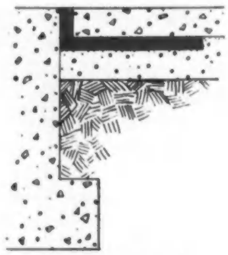
As perimeter insulation, one-inch thick plastic boards may be employed in horizontal or vertical positions. In horizontal installation, as shown here, the material is simply laid around the perimeter of the home. The concrete for the floor is then placed over the vapor barrier and the plastic foam insulation.



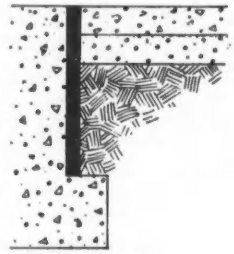
pavement were constructed in this fashion in the state of Michigan last year, and reports indicate a marked improvement in the riding quality of the joints. Costs are also reported to be favorable.

In the case of the dam construction project, the plastic insulation planks are being used to prevent sudden temperature fluctuations which might result in the formation of hairline cracks in the bulkheads. One- by 12-inch planks 9 feet long are nailed to plywood sheets and held in place on the exposed bulkheads with 2- by 6-inch vertical walers. Most of the material used in this fashion can be salvaged and reused.

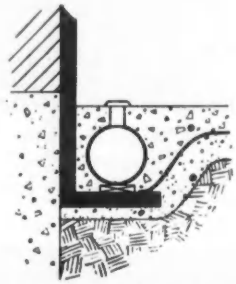
These at the moment appear to be the principal uses of this rigid plastic foam insulation in concrete construction work. But a product with so many intriguing properties is bound to show up in lots of places, and it's a safe bet that you'll be hearing more about it in the busy years just ahead. END



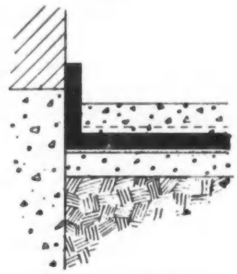
horizontal perimeter insulation



vertical perimeter insulation



perimeter heating



slab insulation

During construction of the Table Rock Dam project, near Branson, Missouri, plastic foam planks were used to protect concrete from rapid temperature changes. The material is clearly visible. Most of it was salvageable and used more than once.

When an increasing number of construction firms go out of business in the middle of a building boom, it's time to ask . . .

Are Contractors Taking Too Many Risks?

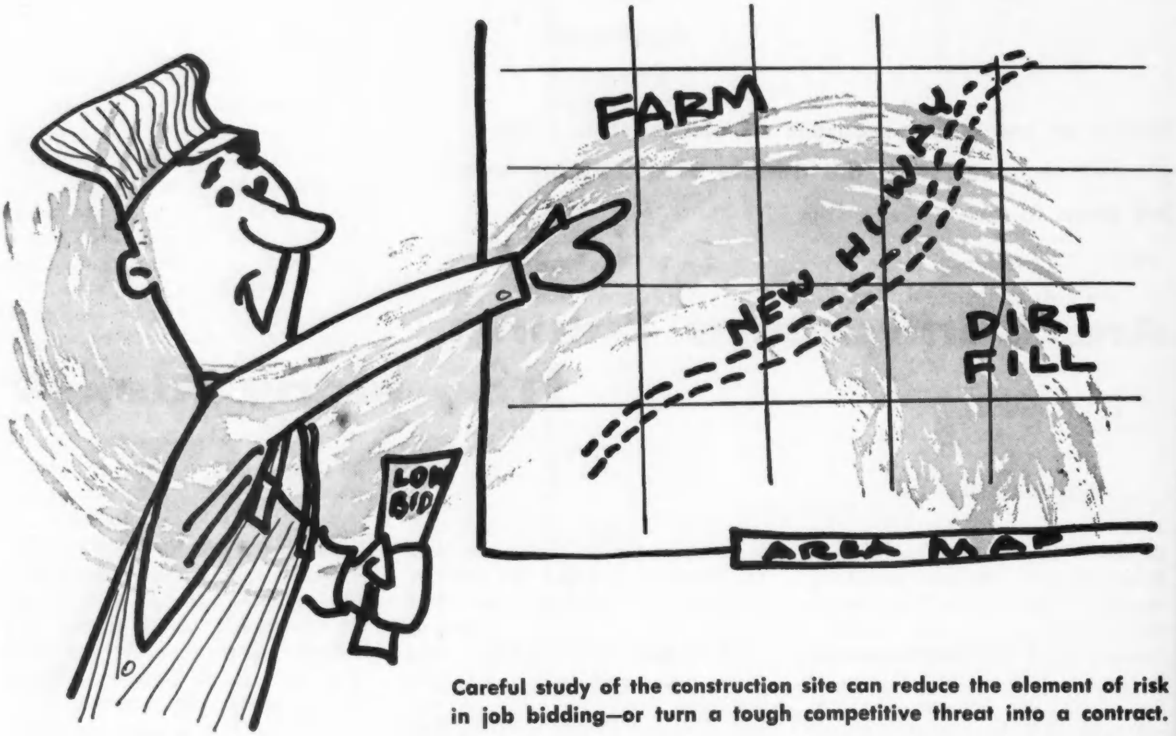
BAFFLING TO BUILDERS and Dun & Bradstreet alike are the increasing number of construction firms that go out of business each year—despite a record high in construction activity. In the first half of 1956, failures in the building line increased by 31 per cent, whereas failures in all the other lines increased only 14 per cent. What makes the building contractor twice as vulnerable as his fellow businessman to the storm and stress of our competitive economy? It's a question that is well worth some consideration.

Contracting to build a factory or a series of homes, like all business enterprises, implies risk on the part of the person or firm that undertakes the job, and risk always implies the possibility of failure. The only safeguard for turning this element of uncertainty into gain instead of loss is a thorough and realistic appraisal of every job that comes up for a bid. And yet in these times, this common-sense business axiom seems difficult to put into practice.

In the first place, the tremendous demand for the contractor's services has created an atmosphere so highly competitive that it isn't easy to be realistic about a price bid and still stay in the bidding picture. A much more powerful deterrent to a common-sense approach, however, is the temptation in a boom period to take unlimited risks. When the present level of business activity is sound and the future looks secure, it's a great temptation for a contractor to overextend his capital and materials—even when completion of a particular job may depend on factors outside his control.

Let's take an example from the Dun & Bradstreet reports. A contractor who had successfully taken a few flyers by borrowing the money to build a row of homes or an apartment building or a factory here and there prior to 1954 at last landed a job to build a $2-million-dollar factory for a manufacturer who wanted to relocate to escape labor trouble. It was agreed that the contractor on completion of the building was to lease it to the manufacturer, and on the basis of this agreement to lease he was once again able to obtain financing. His own finances at the time presented a sound picture—his balance sheet showing a net worth of $545,000.

But on this venture one of the factors outside his control went wrong. The man who had agreed to finance the construction of the factory died suddenly and the contractor was faced with this problem himself. He knew his own assets couldn't carry it, so he went to several finance companies. They all turned him down on the basis of their own appraisal of his future tenant—they did not consider the manufacturer a sound risk since the location of the new factory was not far enough removed from the labor problems he was presumably escaping. The contractor had no choice then but to use his own funds, for men and ma-



Careful study of the construction site can reduce the element of risk in job bidding—or turn a tough competitive threat into a contract.

terials were already lined up for the job. By fall of the same year in which he had agreed to take on this project with inadequate capital of his own to back it up, he was out of business.

Another case from the Dun & Bradstreet records offers quite a contrast in business thinking. This contractor, though faced with a tough competitive situation, applied some pretty shrewd observations and a little imagination to the problem. Instead of just dropping his price to leave little or no profit margin, he came up with a successful solution that earned him a much-wanted highway contract.

The requirements of the job were to complete a stretch of highway over an area that included two obstacles: a creek and a farm. When this particular highway contractor bid on the job, one of his first moves was to take an option on the farm. It was a move that puzzled his competitors, but later turned out to be the explanation for his winning bid.

The first thing he did with the farmland was to remove the top soil. He then hauled the sub soil to the highway site nearby for grading. (His competitors in their bids had figured long distances of hauling dirt for this very same purpose.) But that isn't all —let's get back to the creek. This, of course, had to be drained, and here again a little careful observation on the contractor's part brought a profitable answer. He carried the swampy earth of the creek bed back to the farmland and, once it had dried out, it proved to be very fertile soil. And so when the highway job was finished at a profit, he sold the farm at a profit as well!

Maybe the circumstances of this second case are such that they won't be duplicated every day of the week. But the case nevertheless is an outstanding example of how under competitive conditions, men and companies sometimes turn up the most ingenious solutions to their problems.

Competition is ruinous to a contractor when it is linked with weaknesses inherent in his own business practices. These weaknesses, according to the Dun & Bradstreet findings, are:

Inexperience—either with the nature and problems of the construction industry or with sound business practice and accounting procedures in general.

Underbidding—or taking on jobs with no examination of actual costs involved and the relation of these costs to a sound bid that includes a fair profit margin.

Overextension—or taking on jobs for which there is inadequate capital on hand to back the investment in manhours and machinery.

Just one of these weaknesses in the rough-and-tumble competition of the contracting business could add enough weight to the element of risk to tip the scales in the direction of failure. If too many contractors are ignoring these weaknesses in the mistaken belief that in good times like these you just can't help but succeed—with or without the necessary qualifications—it could well explain the paradox of so many going broke in the middle of a boom. END

Failures of Construction Firms on the Rise

Year	Number of Failures	Percentage of Total Business Failures
1939	646	4.4%
1955	1,404	12.8%
1956 (5 mos.)	702	13.0%